(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 253 734 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
30.10.2002 Bulletin 2002/44

(51) Int Cl.[7]: H04J 3/16

(21) Application number: 02011150.6

(22) Date of filing: 27.08.1998

(84) Designated Contracting States:
BE DE ES FR GB IE IT NL

(30) Priority: 05.09.1997 GB 9718831

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
98306893.3 / 0 901 306

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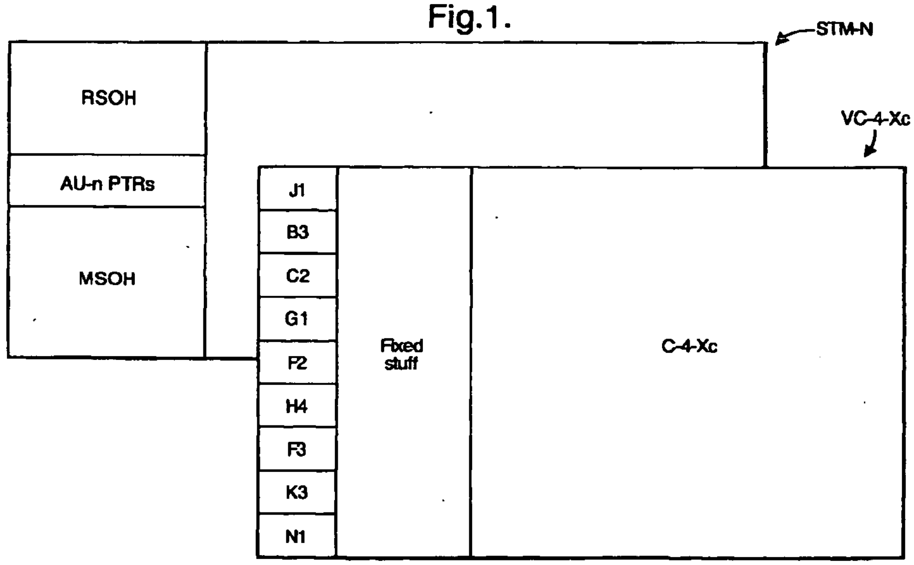
Remarks:
This application was filed on 21 - 05 - 2002 as a divisional application to the application mentioned under INID code 62.

(54) Data transmission in an SDH network

(57) A method for the transmission of data in a synchronous digital hierarchy (SDH) network comprising the steps of transmitting to a node of the network a form of data signal from outside the network, converting the signal into a virtually concatenated information structure and transporting the signal through the network in the virtually concatenated information structure; means for carrying out the method and tributary cards arranged and configured to process signals received in contiguously concatenated form to convert them into virtually concatenated form for transfer across the network; thus providing for data transmitted in high-bandwidth, contiguously concatenated signals (ie VC-4-4c) to be transported across a SDH network, not itself capable of carrying contiguously concatenated signals.

Fig.1.



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Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates to the field of synchronous digital hierarchy (SDH) networks and data transmission therein.

[0002] In SDH data is transferred in information structures known as virtual containers. A virtual container (VC) is an information structure within SDH which consists of an information payload and path overhead (POH). There are two types of VC: low order (LOVC) and high order (HOVC). LOVCs (eg. VC-12, VC-2 and VC-3) are for signals of less than 140Mb/s and HOVCs (ie. VC-4) are for 140Mb/s signals.
With the ever increasing demand for higher data rates there is a continuing need to improve the data transfer capability of networks such as those based on SDH. One way of providing higher bandwidth is concatenation.

[0003] Concatenation is a method for the transport over SDH networks of a payload of a bandwidth greater than the capacity of the defined information structures. ITU standard G.707 defines concatenation as follows: a procedure whereby a multiplicity of virtual containers is associated one with another with the result that their combined capacity can be used as a single data container across which bit sequence integrity is maintained. Two types of concatenation have been proposed: contiguous and virtual.

[0004] Contiguous concatenation is defined in ITU standards such as G.707. Virtual concatenation for VC-2 has also been identified in ITU G.707 but the means for implementing it has not previously been defined and it has therefore not been implemented. Virtual concatenation for VC-4 has been proposed as a concept but no way of implementing has been devised until now. Furthermore, no method of performing conversion between contiguously concatenated signals and virtually concatenated signals has been defined.

[0005] Contiguous concatenation uses a concatenation indicator in the pointer associated with VC's with which the pointers are associated are concatenated for example, by each concatenated frame to indicate to the pointer processor in the equipment that the contiguously concatenating four VC-4s an information structure with a data rate equivalent to a VC-4-4c could be created. The resulting VC-4-4c equivalent signal has only one path overhead (i.e. 9 bytes only). However many installed SDH networks cannot carry out the necessary processing to support contiguous concatenation. In order to implement contiguous concatenation in such SDH networks it would be necessary to modify the hardware of the equipment in order to handle the concatenated signal. Suitable modification of such a network would be prohibitively expensive.

[0006] This can cause a problem when the customer wishes to transfer data which requires a bandwidth too high for the installed SDH network to handle, such as some broadband services. For example a customer may wish to transfer data in VC-4-4c format but would be unable to transport it over current SDH networks which do not support concatenation. US 5, 168 494 (MUELLER-Siemens) relates to a method of concatenation of tributary units or tributary unit groups across a synchronous digital system in which the units are transmitted independently. WO 96 33563 (IBM) describes concatenation, e.g. of four VC-4 in an STM-4 signal. The object of the invention is to provide an SDH network with the capability of carrying signals of increased bandwidth. A further object is to provide for the information content of an STM signal carrying data in contiguously concatenated virtual containers to be transmitted over an SDH network not itself capable of carrying contiguously concatenated signals.

[0007] The present invention provides a method for the transmission of data in a virtually concatenated information structure, in which the virtually concatenated information structure comprises path overhead and a plurality of frames, the method for transmitting the data in a frame sequence including the step of using a part of the path overhead to indicate the frame sequence in the virtually concatenated information structure.

[0008] The present invention also provides a virtually concatenated information structure comprising a plurality of frames for carrying data in a frame sequence, in which the virtually concatenated information structure comprises a path overhead in which a part of the path overhead comprises means for indicating the frame sequence in the virtually concatenated information structure.

[0009] In preferred embodiments, the invention provides a network management system, a tributary interface, a communications network, an asynchronous transfer mode (ATM) communications network and a synchronous digital hierarchy communications network.

[0010] The present invention also provides a method for the transmission of data in a synchronous digital hierarchy (SDH) network comprising the steps of transmitting to a node of the network a form of data signal from outside the network, converting the signal into a virtually concatenated information structure and transporting the signal through the network in the virtually concatenated information structure in which conversion of the signal comprises processing a path overhead of the signal.

[0011] The present invention also provides a synchronous digital hierarchy (SDH) network for carrying data in a virtually concatenated information structure, the network comprising tributary interfaces arranged and configured to process a signal received in a first form to convert it into virtually concatenated form for transfer across the network characterised in that the interfaces comprise means for processing the path overheads of the signal comprising means for using a part of the path overhead to indicate the sequence of frames in the virtually concatenated information structure.

[0012] In a preferred embodiment the data transfer is

achieved by means of a virtually concatenated information structure equivalent to VC-4-4c comprising a set of four virtually concatenated VC-4 signals. This virtually concatenated information structure is referred to in the following by the acronym "VC-4-4vc": this being chosen to reflect the fact that the data rate is the same as that of VC-4-4c, with the "vc" indicating virtual concatenation.

[0013] An embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which

Figure 1 shows the information structure of a higher order, VC-4 signal of the prior art;
Figure 2, shows part of the structure of a lower order, VC-2 signal of the prior art;
Figure 3 shows the structure of a lower order, VC-12 signal of the prior art.

[0014] Referring to Figure 1, this shows synchronous transfer module STM comprising a section overhead SOH, a pointer and a virtual container VC. The VC in turn comprises a path overhead POH, fixed stuff bytes and a container C for the payload.

[0015] A network management system manages the transfer of virtually concatenated VC-4s without any modification being required to network equipment. The only hardware modification required is the provision of modified tributary cards capable of identifying the receipt at the network boundary of contiguously concatenated VC-4s and processing them accordingly. Individual VC-4s and virtually concatenated VC-4s are transported in the SDH network in the same way. Hence, four VC-4s, when virtually concatenated, will still have four path overheads.

[0016] In the standard configuration a tributary card accepts at its input and delivers at its output an STM-4 signal containing four independent VC-4s (by way of example, each may contain a 140Mb/s, 3 x 34Mb/s or 63 x 2Mb/s mapped PDH signals). However, the new tributary card is also capable of accepting at its input and delivering at its output an STM-4 signal containing four contiguously concatenated VC-4 signals: as for example may arise from mapping ATM cells into STM-4 to ITU recommendations 1.432 and G.707.

[0017] The tributary card will recognise the format of the incoming STM-4 signals: as a contiguously concatenated signal using the concatenation indication in the pointer and act accordingly.

[0018] Optionally, the tributary card could also be configured to handle STM-4 signals containing four virtually concatenated VC-4 signals, to meet future demand. The tributary card STM-4 interface meets the requirements of G.957 and G.958. The transport of the ATM/STM-4 signal over the SDH network is transparent and SDH parameters processing and performance monitoring shall apply according to G.826, G.707, G.783 and ETS300 417.

[0019] At the ATM/STM-4 input port the pointers of the four concatenated VC-4s are aligned. The resulting, newly generated four VC-4s are processed for transfer across the network as a virtually concatenated information structure (VC-4-4vc) signal by processing their associated path overheads as follows.

[0020] Whereas the pointer can indicate delay of the concatenated VC-4s in the VC-4-4vc of up to one frame duration (i.e. 125 μs) higher delays cannot be picked up in this way. Since the differential delay between the VC-4s of a VC-4-4vc as they are transported across the SDH network are unknown, it is necessary to take steps to ensure that the VC-4s so transferred are in the correct sequence. The path trace (J1) value for each of the VC-4's in the VC-4-4vc is given a unique code indicating their order within the VC-4-4vc.

[0021] It is also necessary to ensure that the frames of each VC-4 in the VC-4-4vc are correctly ordered. The H4 byte is therefore used for frame sequence indication (FSI) to allow the network to recover the original sequence.

[0022] A signal label code is inserted in the C2 byte of each VC-4 of the VC-4-4vc to indicate the payload type, eg an ATM payload, as required. The B3 byte of the received contiguous VC-4-4c signal is processed, as appropriate, to maintain the path integrity.

[0023] On the back-plane port of the network node which receives the VC-4-4vc signal the virtually concatenated VC-4s of the VC-4-4vc are aligned using a buffer according to the information provided by the path trace values and the frame sequence values. The size of the buffer is dependent on the maximum differential delay allowed between the VC-4s which constitutes the VC-4-4vc. A value of 8 milliseconds is proposed, by way of example, based on the use of the H4 byte to indicate the frame sequence. However such a buffer size may prove prohibitively large. Therefore it may be necessary to reduce the buffer size by ensuring that the differential delay is kept to the absolute minimum. This may be achieved by ensuring that the four VC-4s in the VC-4-4vc are processed and switched together as well as being transmitted together in the same synchronous transfer module (STM), e.g. STM-4, STM-16, STM-64, and along the same route through the network.

[0024] Path trace mismatch on any of the VC-4 in the VC-4-4vc will result in trace mismatch defects on the VC-4-4vc signal. Similarly, signal label mismatch and loss of signal (LOS) of any VC-4 in the VC-4-4vc will result in alarm indication signal (AIS) in the VC-4-4vc.

[0025] The contents of the pointers, concatenation indicators and path overhead bytes of the contiguous concatenated VC are transported in other bytes or bits in the virtually concatenated VC. Suitable unused bits include some path overhead bytes of the virtually concatenated VC that are assigned to functions not used during virtual concatenation and the fixed stuff bits of the container four (C4) that forms part of the VC-4.

[0026] The pointers, concatenation indicators and

path overhead bytes must be restored as appropriate before the signal is transmitted as a contiguous signal outside the network. The path overhead information in the first VC-4 frame in the received virtual concatenated VC-4-4vc signal is inserted in the path overhead of the contiguous concatenated VC-4-4c signal generated by the network for transmission outside the network. Additionally, the B3 value is corrected as appropriate to maintain the paths integrity and is inserted in the contiguous VC-4-4c path overhead. Thus the output port delivers an STM signal identical to that presented at the input port.

[0027] In a typical system performance reports and alarms would be passed to the element manager (EM). The EM (and SDH network management system) may be required to configure the VC-4's which constitute the VC-4-4vc in a preferred manner.

[0028] The invention is not limited to only VC-4-4c or VC-4-4vc. The invention applies to any number of VC-4s (ie. VC-4-nc or nvc where n may be in the range of 2-64 or higher)

[0029] The above embodiment is described by way of example only and does not limit the scope of the invention. In particular the present invention applies equally to signals and information structures other than VC-4, for example to VC-3, VC-2 and VC-1. Virtual container signal structures (including VC-4, AU3/VC-3, TU3/VC-3, VC-2 and VC-12) are defined by the ITU, for example in ITU-T G.707 (Draft) 11/95 published 1995.

[0030] The arrangement and method of this invention as described above in relation to VC-4 also applies to VC-3 signals. In particular the path overhead of these two signals is exactly similar, allowing the same method for processing of overhead bytes to be used for both types of signal. This applies equally to administrative unit three (AU3) VC-3 as to tributary unit three (TU3) VC-3 signals.

[0031] Referring to Figure 2, this shows part of the structure of a lower order virtual container VC-2. In Figure 2 only the first column of the VC-2 is shown to illustrate the positioning of the path overhead (POH) bytes V5, J2, N2 and K4. Also shown are fixed stuff bits R and data bits D. The fixed stuff bits of the first column make up eight whole bytes and other stuff bits and bytes are included in subsequent columns (not shown). The subsequent columns (not shown) comprise further data bits and bytes, together with overhead bits, justification opportunity bits and justification control bits the precise function of which is not relevant to the present disclosure but is detailed in the above ITU-T publication.

[0032] Referring to Figure 3, this shows the structure of a lower order virtual container VC-12 with path overhead (POH) bytes V5, J2, N2 and K4. Data is carried in three units of 32 bytes plus one unit of 31 bytes. Other bytes are variously made up of fixed stuff bytes R, overhead bits O, justification opportunity bits S, justification control bits C and data bits D. The fixed stuff bits R make up five whole bytes and parts of three other bytes with a total of 49 bits. The precise functions of the other bits are not relevant to the present disclosure but are also detailed in the above ITU-T publication.

[0033] With lower order VCs (ie VC-2s and VC-1s) the conversion of the path overhead bytes will be slightly different. Accordingly to the invention, the contents of the V5, J2, N2 and K4 overhead bytes of the contiguous concatenated VC-2 and VC-1 signals (e.g. VC-2-5c or VC-12-4c), are transported in other bytes or bits in the virtually concatenated VC-2s/VC-1s. Suitable unused bits are the fixed stuff bits R or overhead bits O. These overhead bytes are restored before the signal is retransmitted as a contiguous signal outside the network.

[0034] Thus VC-4, VC-3, VC-2 and VC-1 can all be transmitted as virtually or contiguously concatenated signals over ATM or PDH networks.

Claims

1. A method for the transmission of data in a virtually concatenated information structure, in which the virtually concatenated information structure comprises path overhead and a plurality of frames, the method for transmitting the data in a frame sequence including the step of using a part of the path overhead to indicate the frame sequence in the virtually concatenated information structure.

2. The method as claimed in Claim 1 in which the path overhead comprises H4 bits, the method including the step of using the H4 bits for indicating the frame sequence.

3. The method as claimed in Claims 1 or 2 in which the virtually concatenated information structure comprises virtual containers and the path overhead comprises J1 bits, the method including the step of using the J1 bits to indicate the order of the virtual containers in the virtually concatenated information structure.

4. The method as claimed in Claims 1 to 3 in which the path overhead comprises B3 bits for providing an error indication, the method including the step of correcting, as necessary, the error indication information carried in the B3 bits.

5. A virtually concatenated information structure comprising a plurality of frames for carrying data in a frame sequence, in which the virtually concatenated information structure comprises a path overhead in which a part of the path overhead comprises means for indicating the frame sequence in the virtually concatenated information structure.

6. The virtually concatenated information structure as claimed in Claim 5 in which the path overhead com-

prises H4 bits for indicating the frame sequence.

7. The virtually concatenated information structure as claimed in Claims 5 or 6 comprising virtual containers in which the path overhead comprises J1 bits for indicating the order of the virtual containers.

8. The virtually concatenated information structure as claimed in Claims 5 to 7 in which the path overhead comprises B3 bits for providing an error indication.

9. The virtually concatenated information structure as claimed in Claims 5 to 8 in which the virtually concatenated information structure comprises a virtual container four (VC-4) or virtual container three (VC-3) or an administrative unit three (AU3).

10. The virtually concatenated information structure as claimed in Claims 5 to 8 in which the data signal from outside the network comprises a virtual container two (VC-2) or a virtual container one (VC-1).

11. A network management system for managing the transfer of data in a network in the virtually concatenated information structure as claimed in Claims 5 to 10.

12. A tributary interface for the transmission of data in the virtually concatenated information structure of Claims 5 to 10.

13. A communications network for the transmission of data in the virtually concatenated information structure of Claims 5 to 10.

14. An asynchronous transfer mode (ATM) communications network according to Claim 13.

15. A synchronous digital hierarchy communications network according to Claim 13.

16. A method for the transmission of data in a synchronous digital hierarchy (SDH) network comprising the steps of transmitting to a node of the network a form of data signal from outside the network, converting the signal into a virtually concatenated information structure and transporting the signal through the network in the virtually concatenated information structure in which conversion of the signal comprises processing a path overhead of the signal.

17. The method as claimed in Claim 16 comprising the step of converting the signal so transported into a signal of the same form as that transmitted to the network in which conversion of the signal comprises processing a path overhead of the signal.

18. The method of Claim 16 or 17 in which the signal transmitted to the network from outside the network is in contiguously concatenated form.

19. The method as claimed in Claims 16 to 18 which the data signal from outside the network comprises a virtual container four (VC-4) or virtual container three (VC-3) or an administrative unit three (AU3).

20. The method as claimed in Claim 19 in which the path overhead comprises H4 bits and the VC-4 and VC-3 comprise a plurality of frames, in which the step of processing the path overhead including the step of using the H4 bits for indicating frame sequence within the VC-4 or VC-3.

21. The method as claimed in Claim 19 or 20 in which the path overhead comprises J1 bits and the VC-4 and VC-3 comprise a plurality of frames, in which the step of processing the path overhead including the step of using the J1 bits to indicate the order of VC-4s or VC-3s in the virtually concatenated information structure.

22. The method as claimed in Claim 21 comprising the steps of transmitting to a node of the network a signal from outside the network in a form comprising four contiguously concatenated VC-4s and processing the four VC-4s into a virtually concatenated information structure comprising virtually concatenated VC-4s for transfer across the network.

23. The method as claimed in Claim 21 comprising the steps of transmitting to a node of the network a signal from outside the network in a form comprising five contiguously concatenated VC-3s and processing the five VC-3s into a virtually concatenated information structure comprising virtually concatenated VC-3s for transfer across the network.

24. The method as claimed in Claim 22 or 23 comprising the step of aligning the virtually concatenated virtual containers (VCs) of the virtually concatenated information structure using a buffer.

25. The method as claimed in Claim 24 comprising the step of controlling the alignment according to the contents of bytes J1 and H4.

26. The method as claimed in Claims 22 to 25 comprising the steps of switching and transmitting the VC-4 or VC-3 frames of the virtually concatenated information structure through the network together in a single synchronous transfer module (STM) or in multiple STMs and via the same route.

27. The method as claimed in Claim 17 or 18 in which the data signal from outside the network comprises

a virtual container two (VC-2) or a virtual container one (VC-1).

28. The method as claimed in Claim 27 in which the path overhead comprises V5, J2, N2 and K4 bits and in which the step of processing the path overhead includes the step transferring the contents of the path overhead bytes to unused parts of the signal.

29. The method as claimed in Claim 28 comprising the steps of transmitting to a node of the network a signal from outside the network in a form comprising two or more contiguously concatenated VC-2s or VC-1s and processing the VC-2s or VC-1s into a virtually concatenated information structure comprising virtually concatenated VC-2s or VC-1s for transfer across the network.

30. The method as claimed in Claim 29 comprising the step of aligning the virtually concatenated VCs of the virtually concatenated information structure using a buffer.

31. The method as claimed in Claim 30 comprising the step of controlling the alignment according to the contents of the path overhead byes transferred to the unused part of the signal.

32. The method as claimed in Claims 29 to 31 in which the contiguously concatenated VC-2s or VC-1s received from outside the network comprise a plurality of frames in a set sequence, and in which the sequence of the frames may change whilst being transported through the network, the method comprising the step of re-ordering the frames into the set sequence as required.

33. The method as claimed in Claims 29 to 32 in which the VC-2s and VC-1s comprise a plurality of frames, the method comprising the steps of switching and transmitting the VC-2 or VC-1 frames of the virtually concatenated information structure through the network together in a single synchronous transfer module (STM) or in multiple STMs and via the same route.

34. The method as claimed in Claims 17 to 33 comprising the step of recognising the receipt of a signal in concatenated form by the network.

35. A synchronous digital hierarchy (SDH) network for carrying data in a virtually concatenated information structure, the network comprising tributary interfaces arranged and configured to process a signal received in a first form to convert it into virtually concatenated form for transfer across the network **characterised in that** the interfaces comprise means for processing the path overheads of the signal comprising means for using a part of the path overhead to indicate the sequence of frames in the virtually concatenated information structure.

36. The network as claimed in Claim 35 in which the tributary interfaces are arranged and configured to process a signal transferred across the network in the virtually concatenated form and to convert it into the first form.

37. The network as claimed in Claim 36 in which the signal in virtually concatenated form comprises virtual containers (VC) and the tributary interfaces comprise one or more buffers for ordering said virtual containers (VC).

38. The network as claimed in Claims 35 to 37 in which the signal transmitted to the network from outside the network is in contiguously concatenated form

39. The network as claim in Claim 38 in which the tributary interfaces are configured and arranged to detect the receipt of a signal in contiguously concatenated form by detecting a concatenation indication of the signal received.

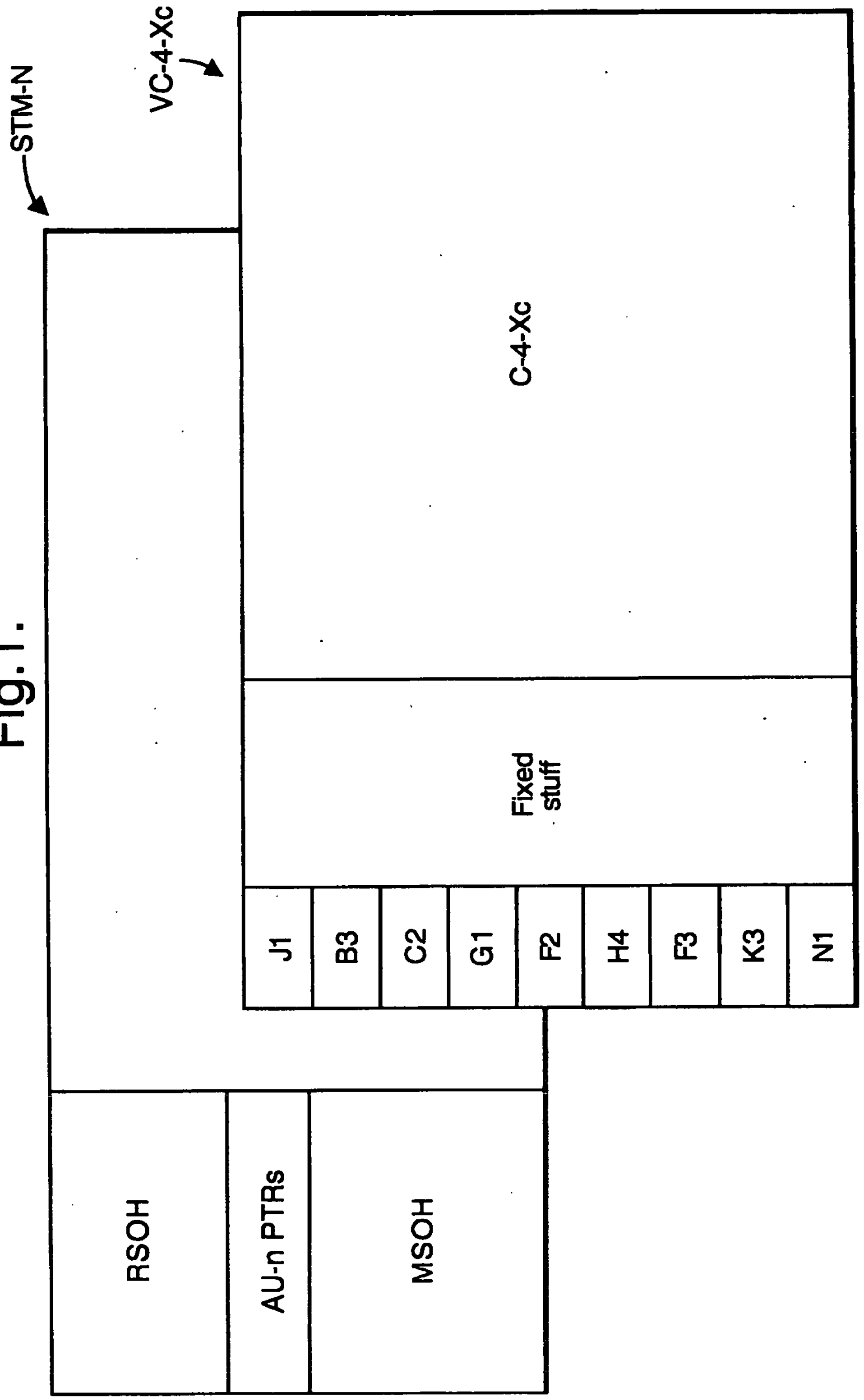
STM-N
VC-4-Xc
C-4-Xc
Fixed stuff
J1
B3
C2
G1
F2
H4
F3
K3
N1
RSOH
AU-n PTRs
MSOH

Fig.1.

Fig.2.

V5
R R R R R R R R
D D D D D D D D
R R R R R R R R
J2
R R R R R R R R
D D D D D D D D
R R R R R R R R
N2
R R R R R R R R
D D D D D D D D
R R R R R R R R
K4
R R R R R R R R
D D D D D D D D
R R R R R R R R

Fig.3.

V5
R R R R R R R R
32 BYTES
R R R R R R R R
J2
C_1 C_2 O O O O R R
32 BYTES
R R R R R R R R
N2
C_1 C_2 O O O O R R
32 BYTES
R R R R R R R R
K4
C_1 C_2 R R R R R S_1
S_2 D D D D D D D
32 BYTES
R R R R R R R R